AD NUMBER
AD386933
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; JUN 1967. Other requests shall be referred to Defense Advanced Research Projects Agency, 1400 Wilson Blvd., Arlington, VA 22209.
AUTHORITY
30 Jun 1979, per document marking, DoDD 5200.10; DARPA ltr, 5 Sep 1975

AD NUMBER

AD386933

CLASSIFICATION CHANGES

TO

confidential

FROM

secret

AUTHORITY

30 Jun 1970, per document marking, DoDD 5200.10

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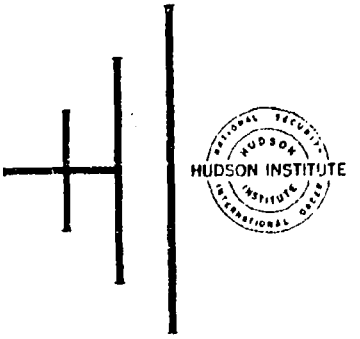
A BOAT MARKING SYSTEM FOR USE IN THE SOUTH VIETNAMESE DELTA (U)

Thomas F. Bartman



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By
Thomas F. Bartman

HI-809-RR June 16, 1967

This report was prepared for the Advanced Research Projects Agency, Department of Defense, under Contract No. DAHC 04-67-C-0003.

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A BOAT MARKING SYSTEM FOR USE IN THE SOUTH VIETNAMESE DELTA (U)

I. INTRODUCTION

The strategic importance of the Mekong Delta is now well recognized, and in many ways the Delta provides a testing ground for the Asian Communist's theories of guerrilla war. Although there are no known North Vietnamese troops in this area and it is at the farthest reaches of the enemy supply line stretching down from North Vietnam, the Viet Cong often seem to exert varying degrees of political and economic control throughout much of the region. While the introduction of North Vietnamese units has altered the nature of the fighting in much of the northern part of South Vietnam, the Mekong Delta remains a true guerrilla war.* It is the largest and by far the most important area in which we are faced by a largely indigenous, irregular force.

The recent decision to commit significant American ground forces to the Delta is a recognition of the strategic importance of this area, and the performance of these units is critical to the outcome of the war. U.S. troops have proven their ability to defeat and destroy the regular enemy formations sent down from the North, but the war in the Delta poses the much more complicated political, social, economic, and military interrelationships of guerrilla warfare for free world forces.

If the Delta is the key to South Vietnam, then the rivers, canals, swamps and paddies are the key to the Delta. The small boat is to the people of this area what the family car is to the inhabitants of suburban America. During much of the year, most of the inhabited areas are

*This does not imply that only small Viet Cong units operate in the Delta, as the Viet Cong often mount battalion size operations.

surrounded by water, and boats provide the only method of transportation. Even during the dry seasons, water transport often is the most efficient and fastest method of traveling. At the present time, however, the thousands of miles of inland waterways in the Mekong Delta confer a myriad of advantages on the enemy. Some of these advantages are briefly listed below:

1. They provide the enemy with fast lines of communication and supply.

2. They allow the enemy to rapidly assembly and disperse for offensive action.

3. They allow the V.C. to hide among the heavy flow of legitimate civilian water traffic.

4. Because the inhabitants of the Delta are dependent on the internal waterways for transportation to move their goods to market and to ship necessary products from the larger urban centers, the enemy has been able to collect large amounts of supplies moving on these water routes as taxes.*

5. Present tables of organization make it very difficult for friendly forces to put enough small patrols on the water routes capable both of surviving potential enemy ambushes and still denying the use of the inland waterways to the enemy.

That the enemy has made good use of these advantages is evidenced by their complete or partial control of many of the areas in the Delta. Intelligence estimates claim that the Viet Cong have somewhere between 4,000 and 7,000 boats engaged in running supplies and men on the Delta's inland waterways.** In addition, the Viet Cong are able to coerce or persuade many South Vietnamese boat owners to employ their vessels on a part time basis

*These taxes are often money payments.

**Weekly Intelligence Summary and Vietnam Report, 20-66, Headquarters, U.S.A., J.F.K. Center for Special Warfare. (SECRET)

for Viet Cong activities. Perhaps the following quote from a study entitled "The V.C. Tactical Use of Inland Waterways in South Vietnam" best summarizes the situation.*

> The V.C. presently have the water transportation capability of moving enough supplies and materials to equip all their forces in the Delta and to indefinitely maintain the present level of combat. They are also capable of substantially increasing the tempo of combat in the Delta with the water-borne supply system remaining relatively unhampered. ...The only restriction they face is interdiction by air. This restriction, however, is effectively countered by moving at night or covertly by day. Presently the V.C. are capable of moving battalion-sized forces by boat.

The major American effort to control enemy water mobility in the Delta is carried out under the code name, "Operation Game Warden." At the present time approximately one hundred, 4-man, 32-foot PBR's are assigned to patrol along the three major rivers of the Delta.** These boats are usually employed in 2-boat patrols, sometimes in conjunction with armed helicopters during daylight and nighttime hours. Table I, found on the following page, summarizes the activities of these boats under "Operation Game Warden" in the month of August, 1966.

While "Operation Game Warden" has met with limited success and is an excellent first step, it has not stopped the enemy's water mobility on the major rivers which it patrols; and it has not even begun to challenge the enemy's ability to move supplies and troops by water in the many side channels and streams outside the reaches of its 2-boat patrols. The major

*Order of Battle Study, 66-44, V.C. Tactical Use of Inland Waterways in South Vietnam, English Edition. Combined Intelligence Center, Vietnam. (CONFIDENTIAL).

**This force will eventually be built up to 120 boats under present plans.

TABLE I

Summary of Game Warden Operations
for August 1966

	Day	Night	Total
Number of Patrols	398	519	917
Total Contacts	35,027	12,613	47,640
Boats Inspected	8,633	2,090	10,723
Boats Boarded and Searched	8,789	1,550	10,339
Suspects Detained	---	---	547
Patrol Hours	---	---	19,631
Average Patrol Length	---	---	9.3 hrs.
Total Possible Monthly Patrols	---	---	2,113

factors which have served to limit the success of Game Warden are listed below:

1. The heavy normal civilian traffic makes it relatively easy for enemy vessels to hide within this traffic, and it is almost impossible for the patrol boats to search thoroughly a significant part of the total traffic.

2. There are few records of normal traffic patterns.

3. There are few effective vessel registration programs.

4. In many areas there is no enforceable curfew except for the major waterways.

5. The inability of the PBR's to enter the many side channels, canals, and central islands of the main rivers which they patrol allows many suspected enemy boats to escape inspection, search, and capture.

As in most of Vietnam there are no continuous front lines in the Delta. Rather there are areas of enemy and government control. Similarly, the internal waterways which serve as the vital communication routes for government, civilian, and enemy activities are divided between government-controlled, enemy-controlled and contested sections.* In addition, there are some rivers and canals which are off-limits to all civilian vessels

*The contested areas are usually nominally controlled by the government forces in daylight and by the enemy during the hours of darkness.

and many more which have nighttime curfews which forbid civilian craft from traveling on them during certain hours of darkness.

However, to be useful as communications and supply routes, vessels engaged in enemy activities must often travel through both off-limit areas and government-controlled sections of rivers, canals and swamps. For unless the enemy wishes to use his water mobility merely on internal lines of supply within areas which he controls, the V.C. must frequently travel in the government-controlled areas so that his widely dispersed forces can communicate and extend their influence. At the present time the enemy does seem to make frequent use of government-controlled and contested waterways as it is relatively easy to hide in the large volume of legitimate traffic. Civilian vessels engaged in normal activities, on the other hand, are less apt to enter enemy-controlled areas, especially at night, or to violate curfews when they are rigorously enforced. The major reasons why legitimate civilian boats are hesitant to enter V.C.-controlled areas of the rivers often have very little to do with their loyalty to the central government, but rather are simple matters of self-interest. The major factors which inhibit heavy civilian traffic in V.C.-controlled areas are: the probability that the V.C. will collect part of their cargoes as taxes, the possibility that the V.C. will impress members of the crew or the boat into their own service, the inconvenience of having to listen to V.C. propaganda harangues, and the fear of American and South Vietnamese aircraft and artillery strikes.

II. USE OF A SIMPLE BOAT MARKING SYSTEM IN THE MEKONG DELTA

Conversations with Navy personnel connected with Game Warden and other related operations revealed that they face a major identification problem in trying to control the V.C.'s water mobility. Since the PBR's are largely restricted to the wide major rivers and cannot penetrate the myriad of smaller channels and canals which run into these rivers, they cannot patrol those areas in which the concentration of enemy boats is apt to be greatest. As it is difficult, if not impossible, to prevent easy entrance and exit from these side channels and canals, the PBR crews have no way to distinguish from the normal traffic flow those boats which had entered known or suspected V.C. base areas. While the knowledge that a boat had entered such an area would not solve all the problems facing Game Warden operations, it could provide the crews with a valuable aid in their patrolling duties.

A simple boat marking system might provide one possible method for a PBR to determine whether a boat, which had been stopped for inspection and/or search, had entered a known V.C. base area or waterway and possibly to trace its route. While such a system and some specific operational uses will be discussed later, it might be helpful to briefly outline one possible basic boat marking system which might be used in the Mekong Delta.

Underwater disseminators would be placed by the patrol boats, aircraft, or ground parties in rivers or canals at points V.C. boats were suspected of crossing.* These devices would release a liquid which would spread across the surface of the water and mark any boat which passed

*These points would usually be on rivers, streams, or canals leading into known enemy base areas. They would be selected to minimize the change of legitimate civilian boats crossing these points.

within approximately 300-600 meters downstream from the disseminators. The chemical would be virtually invisible on the surface of the water, especially at night, and would be invisible to the naked eye on the marked vessel. In addition, it would be possible to use disseminators which would be able to turn themselves on and off, thus giving them the ability to mark only those boats which pass the disseminators during curfew while leaving vessels traveling in daylight unmarked. Also, it is important to note that the marking chemical on the surface of the water usually disperses at a maximum distance of one-half mile from the disseminators.* This means that there would be little danger of marking chemicals drifting into areas where legitimate or friendly vessels are normally stationed or traveled. In other words, it would be possible to lay a fairly well defined strip of marking materials across a canal or river.**

Each PBR would be equipped with some type of ultraviolet and/or infrared light to enable it to detect any vessel which had been tagged by passing through a marked area or waterway. The range of these lights would be from 2-20 meters, depending on the type of lights selected and the degree of darkness. According to men who have participated in Game Warden operations, this would not interfere drastically with their present method of operations, as it is now standard operating procedure to approach close enough to many boats when inspecting or searching them to be well within the range of the detection equipment.

---

*The liquid spreads evenly over the surface of the water; one drop will spread evenly over one square meter or ten square meters of water. It also takes a certain minimum concentration to mark a boat successfully. Thus by the time the marking material drifts about 400 meters downstream, it is so dispersed that it will not mark a vessel.

**Boat Markers (U), Final Report by M. Beacham, M. Nichols, and R. Madison, American Cyanamid Company, ARPA Order No. 256. (CONFIDENTIAL)

The cost of the necessary marking and identification equipment to carry out these operations is relatively small. The cost of the disseminators, including the necessary chemicals, might range from $5-$500, depending on the size of the unit selected. For example, the cost of the disseminators and chemicals to mark a river 300 meters wide for a period of 12 hours would probably be well under $100. The detection devices would range from $50-$1,000, depending on whether ultraviolet, infrared, or some combination of the two were selected.

At first glance, the major drawback to a boat marking system for the Delta is the problem of a potentially high false alarm rate.* Such things as the frequency of curfew violations and mistakes in the location of disseminator devices would inevitably mark a certain number of innocent boats. This system, however, is not designed as a universal answer to the problem of enemy water mobility in the Delta. Rather, it is intended to serve as an aid to operations such as Game Warden, which are presently under way, or other new attempts to hinder the enemy's water mobility. The fact that a boat was marked would not necessarily be taken as complete evidence that the boat was engaged in Viet Cong activities. It could, however, serve as an invaluable aid to patrol boats engaged in Game Warden operations in determining which boats out of the thousands of daily contacts should be subjected to close search. In some cases, especially those in which a boat had several different marking codes on it indicating that it had passed several disseminators on a relatively long journey, marking would be sufficient evidence for at least detention and further interrogation. Also

*This problem will be more thoroughly discussed in a later section giving some specific operational examples of possible uses of a boat marking system.

one or several marked boats traveling with a larger group of unmarked vessels would be highly suspect.

In summary, a boat marking system intelligently applied to specific cases in the Delta might be a substantial aid in helping to hinder the present free movement of enemy vessels on the vitally important internal waterways of this area. To be successful, however, it is essential that the system be employed only on the basis of good, recent intelligence information. In fact, as we shall see in our operational scenarios, the system is designed to make use of the large amounts of general intelligence available to Game Warden operations.

III. EQUIPMENT AND CHEMICALS NECESSARY FOR A BOAT MARKING SYSTEM IN THE DELTA

The necessary equipment and chemicals for a boat marking system can be divided into three basic categories: marking agents, dispersion devices and detection equipment. What follows is a brief discussion of presently available equipment or items which could probably be procured in under six months.*

A. Marking Agents

A great deal of work has been done over the last three years on suitable marking agents. The most suitable chemicals would probably be some type of fluorescent phosphor which would be excited by ultraviolet light. Two basic varieties of phosphors are leading candidate materials for a boat marking system. The first, and simplest, is an ordinary long-wave ultraviolet phosphor which emits a visible glow when excited by an

*Probably most items could be ready in under a month.

ultraviolet light source. The second is a phosphor which, when excited by ultraviolet light, emits in the infrared. The emission of this variety of phosphor is not visible to the naked eye and an infrared imaging device must be used to detect its presence.

There is a wide range of different colors available for coding arrangements, and two or three different types of phosphors could be mixed together to further increase the potential number of usable codes. At the present time there are well over 20 different codes available that can be distinguished by the naked eye. Actually, the probable number of codes which could be employed would run into the hundreds.

The American Cyanamid Company, working under an ARPA-AGILE contract, has developed the necessary dispersing agent to spread the phosphors on the surface of the water.* The marking agent, when combined with the dispersing solution, is hardly visible on the surface of the water, especially at night. In past tests, one gallon of marking solution per hour has been sufficient to effectively mark any boat which passes on a 300-meter wide river within 400 meters downstream of the disperser. Dr. M.T. Beechem, the project head at American Cyanamid, estimates that if the percentage of phosphors to solvent were increased, less than one-half gallon per hour would effectively mark a vessel on the same 300-foot wide river within several hundred yards downstream of the dispersion devices.**

*American Cyanamid Company, ARPA Water Marker, ARPA Order 386, Amendment 13.

**The phosphors are harmless and non-toxic in the quantities which would conceivably be used. For toxicity studies see Appendix I. At last report, however, the disseminating solution could still be detected by some people by its odor at close range.

B. Basic Marking Agent Dispersion and Delivery Systems

1. Underwater Dispersion Devices

For most waterways in the Delta some form of underwater dispersion device would probably be best. While little formal work has been done in developing an operational dispersion device, the necessary devices could be extremely simple. Both Dr. Beechem and Mr. Frank X. Webster of Metronics Associates, Inc., of Palo Alto, California, estimate that no more than one or two months at the most would be necessary to come out with a working prototype of the necessary dispersion devices.

Two basic dispersion device configurations appear practical. The first would be a device similar to that already used by the American Cyanamid Company in its tests. This is simply a metal container with holes cut at the top and bottom. When in the water, the difference in pressure on the top and bottom holes serves to force the marking solution from the container. The size of the openings at either end of the container determine the rate of dispersion. Dr. Beechem indicated that it would be possible to devise the necessary mechanisms to permit this kind of dispersion device to turn itself off and on, thus enabling it to mark an area of a river or canal only during hours of curfew.

The second configuration might be a container for the marking agent and a battery-operated motor which would perhaps power a simple screw-type mechanism which would serve to propel the marking agent into the water at a controlled rate. This device could also have the ability to turn itself on and off.

Figure 1

BOAT MARKING SYSTEM

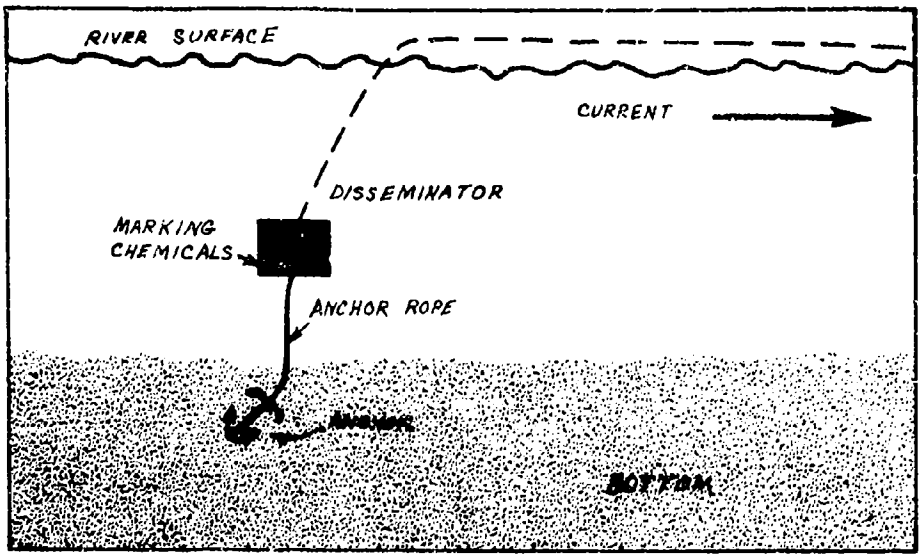
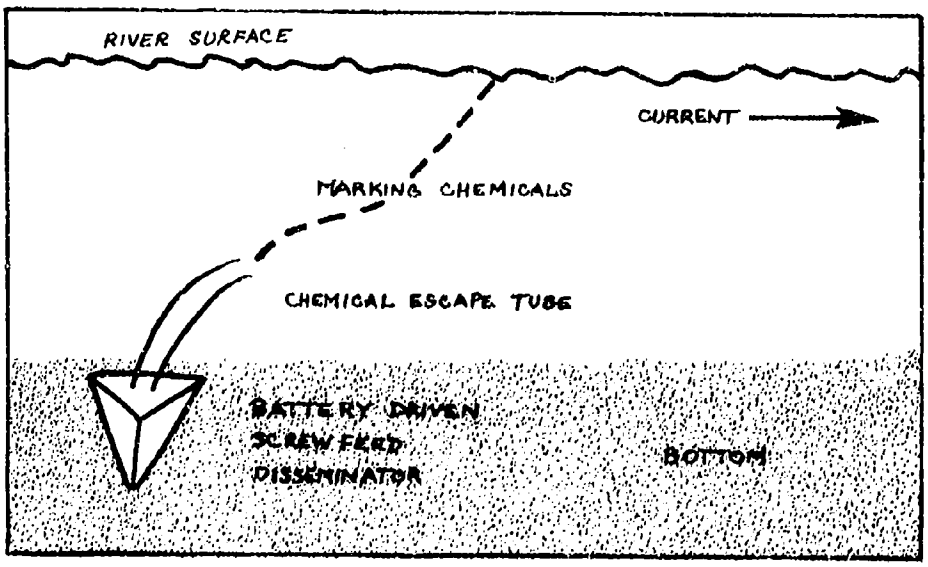


Figure 2
BATTERY DRIVEN, SCREW FED
DISSEMINATOR



2. Size of the Devices

The dispersion devices would come in a variety of sizes depending on the nature of the planned mission and the planned method of delivery. They would range from small quart, perhaps even pint-sized containers, for small relatively slow moving rivers and canals, to large 50-gallon oil drums for larger rivers where long periods of marking capability are desired. For use with a 32-foot long PBR presently employed in Operation Game Warden, the smaller sized dispersers, up to 10 gallons, would probably be best. Crews of these boats say that the larger devices would interfere with the performance and operation of the vessel while they could probably carry up to five three- to five-gallon containers with little trouble.

The larger devices would probably be used when it was necessary to mark a section of waterway for long periods of time, up to a week, while the small containers would be employed when only one or two days of coverage were necessary.

3. Anchoring of Dispersion Devices in the River

Two methods of insuring that the dispersion devices remain in their original position seem possible. The container would be made buoyant and attached to the bottom of the waterway by a rope and anchor. This method would probably have to be used with the simple pressure-activated dispersion devices in order to keep them clear of the mud of the river beds which would clog their intake and escape holes and render them inoperable.

These devices might, however, be vulnerable to sweeping operations if the V.C. discover the nature of the boat marking system and the approximate location of the devices. If this becomes a problem it might be necessary to employ the battery-operated, screw-fed disseminators. These would be

weighted to sink at least partially into the bottoms of the waterways in order to frustrate V.C. sweeping operations.

If even more security was desired the device could be weighted so that it buried itself completely in the bottom leaving only a small tube remaining above the water. This is illustrated in Figure 2 (page 12).

4. Non-Underwater Dispersion Methods

While underwater dispersion devices seem to be most suited for the majority of operational requirements in the Delta of South Vietnam, in some special cases other methods might be profitably employed.

a. Aerial Spraying in Stagnant Areas. Some of the swamp and paddy areas in the Delta are navigable by small shallow-draft sampans. The V.C. use these routes to avoid an especially well-patroled section of waterway or when carrying obvious contraband such as troops or arms. Since these areas are largely stagnant, it might be easier to simply spray them from the air if one desires to mark vessels which travel through these areas. The phosphors would simply be mixed or dissolved in a solution that would keep them afloat for up to a week at a time.

b. Direct Contamination of the Enemy Boats. At the present time it is a fairly common practice to employ a combined team of PBR's and several helicopters on Game Warden missions in the Delta. For there are many small side channels and heavily overgrown center islands with small channels running through them in the major rivers of the Delta, and the PBR's are not able to penetrate these arees. Therefore, enemy vessels which are spotted by the patrol boats and wish to avoid inspection often seek shelter in these side channels or in the center islands. Helicopters are used to locate and attack any vessels which seek to avoid inspection in

this manner. The helicopters, however, often do not succeed in destroying all the boats seeking to escape in such a manner. The addition of a two to five gallon tank and sprayer to one of the helicopters participating in these patrols would enable the pilot to mark virtually all the boats seeking escape in the above-mentioned manner for possible later identification.*

C. Detection Devices

While a wide range of both military and commercial detection devices are available, most of the presently available systems would fall into two categories. The first would be some type of hand-held or ship-mounted ultraviolet light with an effective range of one to twenty feet depending on lighting conditions for use with ultraviolet excited phosphors which emit light visible to the naked eye. The second would be a combination of ultraviolet searchlight, infrared imaging device, and image intensifier for use with phosphors which are excited by ultraviolet light and emit an infrared signal. Various types and capabilities of these lights will be more fully discussed in the following section.

D. Systems Presently Available

The following is a description of two possible boat marking systems which might be available within one to four months of the time from which the decision was made to test them.

*I am a bit hesitant to include this direct contamination portion in this study because of the resistance it has encountered on the grounds that if we can spray them we can shoot them instead. However, several participants in these combined PBR-helicopter operations suggested this idea to me and maintained that it could prove useful without lessening the effectiveness of present operations.

System Number One: Pressure-activated, underwater and/or aerial dispersion device plus simple ultraviolet phosphors plus boat-mounted UV searchlights.

This system would allow the marking of any river or canal for from 100-800 meters from the location of the dispersion devices depending on the rate of dispersion of the marking solution. Any boat passing over this marked section of the river would be tagged. Boats passing at greater ranges than those indicated above would probably be unmarked, especially if they passed more than a mile from the site of the dispersion device. Thus it would be possible to mark a limited and fairly well-defined section of a river or canal. Also, this system could have the capability to turn itself on and off so as to mark a river only during curfew; boats passing the site of the devices when the waterway was legally open to legitimate traffic would not be marked.

Each PBR would be equipped with an ordinary longwave ultraviolet searchlight.* This should enable the crew to determine whether a boat has been marked at ranges up to 10 meters at night and, if the patrol boat provides some shade in daylight hours, at ranges up to 3-5 feet during daylight hours.

System Number Two: Pressure-activated underwater and/or aerial dispersion device plus ultraviolet-excited, infrared-emitting phosphors, plus UV light source and infrared imaging device.

This system would use the same dispersion devices and methods as those employed in system number one. Instead of the simple ultraviolet

*The use of a longwave instead of a shortwave ultraviolet light substantially reduces the danger of eye damage as this is the type of light that is used for commercial ultraviolet lighting effects with perfect safety.

phosphors, however, it would employ a phosphor which, when excited by light, would emit in the infrared. While the simple longwave phosphors employed in system one emit a glow visible to the naked eye, the light given off by these infrared-emitting phosphors can only be detected by using an infrared imaging device similar to that used on present infrared weapons sights.

The advantages of this system over the previous are twofold: first, it permits the identification of a marked vessel without a vessel knowing whether or not it is marked; second, it increases the maximum detection range; at night it would be possible to detect a marked boat at ranges in excess of 10 meters. During daylight hours, however, the detection range of this system would probably still be under 10 feet.

Combination of System One and System Two: As has probably been noted, these two systems can easily be used in combination or sequence. For example, system one, which employs the simple visible-emitting longwave phosphors might be employed first. When the enemy discovers the nature of this system and begins to acquire ultraviolet lights to determine if a boat has been marked, we could then switch to system number two in order to retain some element of surprise and mystery for a longer period.

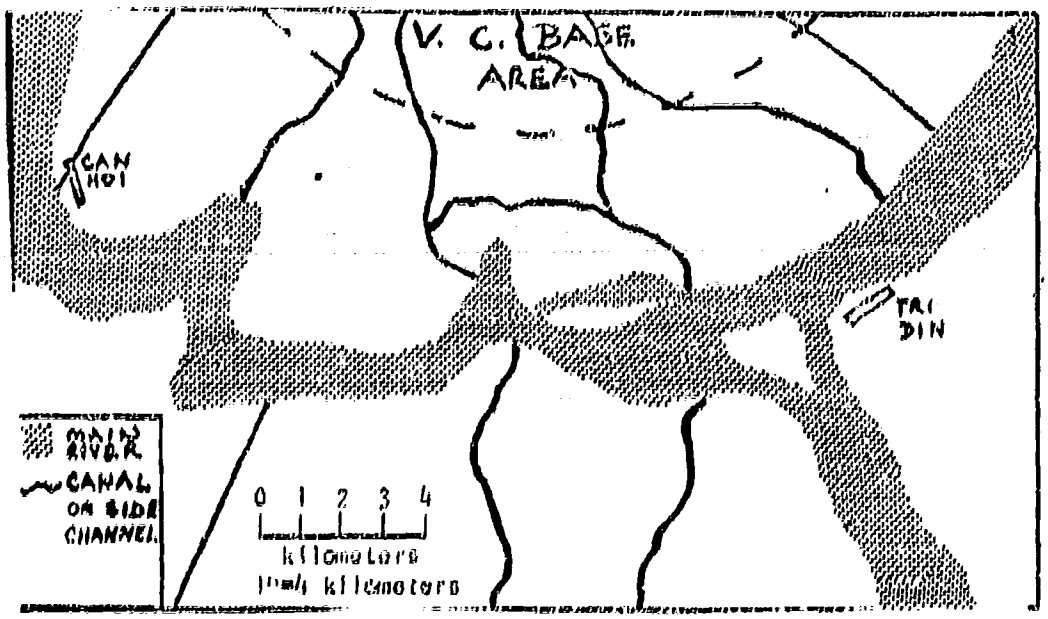
IV. SOME OPERATIONAL EXAMPLES OF POSSIBLE USES OF A SIMPLE BOAT MARKING SYSTEM IN THE DELTA

Perhaps the best method of illustrating the uses of a simplified boat marking system in the Delta areas of Vietnam would be to cite several typical situations and explain how such a system might be employed in each of these cases.

While the topography and situations described below do not begin to cover the broad range of actual situations encountered in the Delta, they are typical of enough of the problems present there to provide an adequate conceptual testing ground for any boat marking system.

MAP 1

A Typical Game Warden Patrol Area



Geographical Setting. On the above map we are presented with a fairly representative geographical picture of the environment in which many of our present Game Warden operations are taking place. Anywhere between 10 and 15 PBR's might be assigned to patrol this 20-30 kilometer stretch of river and Game Warden operations would normally be limited to the main river channels. Notice the extremely large number of side channels, canals and smaller streams and/or rivers which lead off the main channels. The

PBR's, however, do not normally enter these side waterways.* Let us assume that there are two sizable hamlets located on this section of the river, both of which are normally under RVN control and that the PBR's patrolling this stretch of river are based at Tri Dinh. Let us also assume that to the north of the river is a known V.C. base area and that to the south of the river is an area normally under enemy control. The following examples illustrate some of the ways in which a simple boat marking system might be profitably employed in this kind of geographic setting.

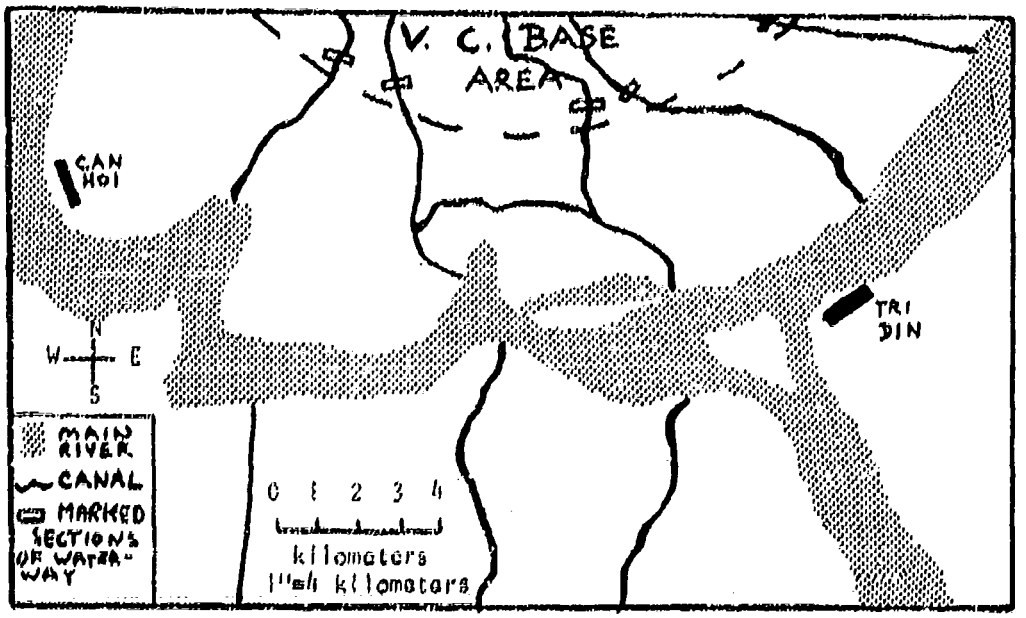
Problem #1: Legitimate Cargoes Destined for V.C. Use

The V.C. use the Mekong Delta as a resource base to feed and support their troops stationed both inside the Delta and in surrounding areas. They must, however, not only acquire the necessary resources but transport them from their place of acquisition to their widely dispersed base areas and forces. Attempts at interdicting the enemy's movements of such items as foodstuffs and medicines has been largely frustrated by the fact that such items are "legitimate" cargoes. For the Delta not only supplies the enemy with much of his food, but is also the major supplier of food for the GVN. Thus, it is almost impossible to distinguish V.C. boats carrying rice, fish, salt, medicines, etc., from the large numbers of other boats carrying exactly the same cargoes. The only difference between the V.C. and normal civilian vessels and cargoes is their final destination.

With reference to Map II on the following page, let us examine the way the V.C. might deliver so-called "legitimate" cargoes to their base

*The PBR's are too vulnerable to mines and ambushes to enter these narrow waterways.

MAP II



areas and why present efforts to hinder such movement have been only marginally effective.

Let us assume that a V.C. food smuggler begins his journey from Tri Dinh in an attempt to supply the V.C. base area north of the main river. In many cases, especially with food and medical supplies, he might actually buy his cargo in Tri Dinh, ostensibly for delivery at another government town further up river. Thus our smuggler will often have the correct papers in his possession during much of his journey.

The V.C. supply boat starts its journey west from Tri Dinh. His only major problem in completing the journey is to slip successfully into one of the many small channels which lead from the major river to his final destination in the V.C. base area. For once he leaves the main channel, he can

no longer be interdicted by the PBR's.* Veterans of Game Warden operations testify to the extremely small likelihood of either apprehending a boat as it enters a side channel or interfering with its delivery of supplies to the enemy once it leaves the main channel under present Game Warden procedures, equipment, and force levels. Moreover, even if an actual V.C. sampan carrying a "legitimate" cargo is stopped, inspected, or searched by a PBR, there is presently no way of distinguishing it from the many identical looking innocent craft carrying exactly the same cargoes.

According to naval officers familiar with such Game Warden operations, a workable boat marking system which didn't interfere with normal operations might be helpful in coping with this problem. If water marking devices were placed approximately at points on the waterways leading into the V.C. base area it could be possible for the PBR's to tell whether a boat which was later stopped by a PBR patrol had entered this area.** If a color coding system were used, it might also be possible to determine the approximate route which the vessel took.

While in most cases the limited range of this system would restrict identification of marked boats to those vessels which the PBR's inspect and/or search, it would still be helpful because at the present time there is no way to identify most V.C. "legitimate" cargo carriers even if they are stopped by patrol boats.*** Of course, the value of such information

*In some areas, however, Vietnamese police or Junk forces might still pose some danger to a V.C. supply boat.

**Possible methods of inserting the dispersing devices into waterways will be discussed at the end of this section.

***Approximately one-quarter to one-third of all boats sighted by PBR patrols come within range of the detection system at the present time under normal operating conditions.

will vary according to the exact nature of each area and situation involved. If the V.C. base area has little permanent population, curfews are generally obeyed by legitimate travelers, or there is little normal traffic on the waterways which lead to the base area, the fact that a boat was marked might be very strong evidence that this boat was engaged in V.C. activities.

In other cases where there is a larger civilian population in the enemy area and some legitimate traffic traveling through this area, the information made available by a boat marking system might be of more marginal, though still considerable, value. For example, it gives the interrogator on the PBR a fact with which to trap a V.C. smuggler in a lie. Also, if used in conjunction with intelligence information, it will help point out V.C. suspects.

Problem #2: Contraband

While it is at the present time very difficult for Game Warden patrols to identify V.C. vessels carrying "legitimate" cargoes, this problem is not as great for boats engaged in carrying obvious contraband. If items such as arms, ammunition, explosives, enemy documents, etc., are found aboard a boat which is searched, there is little doubt that the crew are members of the Viet Cong. Yet the actual identification of such enemy contraband carriers is still often extremely difficult.

The V.C. are experts at concealing contraband cargo: a few of their favorite tricks are listed below.

1. Cargo will often be hidden under extremely difficult-to-remove cargo such as rice, fish, live crabs, etc.
2. Cargo is concealed in a container fastened below the hull of the vessel.

3. Small valuable cargo, such as documents, is almost impossible to find without actually tearing the boat apart.

4. The V.C. will often travel during peak traffic hours to minimize the chances of being searched.

The relatively long amounts of time necessary to thoroughly search a single vessel coupled with the often large volume of normal civilian traffic poses a dilemma for Game Warden operators. If careful searches are made, the number of boats which can be visited on a patrol is reduced; and if only cursory inspections are made, the chances of discovering contraband are minimized.

In addition to careful concealment, the enemy is much more careful in his methods of moving contraband supplies than he is wher carrying "legitimate" cargoes. From our limited knowledge of Viet Cong water supply methods, it seems that the enemy places vessels carrying obvious contraband in areas where there are likely to be patrol boats with much less frequency than it does with "legitimate" cargo carriers. Night travel, elaborate sentry systems, detours, etc., are often employed when moving obvious contraband. Thus not only is it difficult to stop and identify such boats when they do enter patrol areas, but the frequency and length of time which contraband is transported through these areas is probably less than with V.C. "legitimate" cargo.

Also, we find that even when enemy boats are spotted and identified they and/or their crews all too often manage to elude capture or destruction. PBR action reports indicate that even when boat identifies itself as being an enemy by firing on a PBR, the boat and/or its crew often manages to escape. The large number of side channels, shallow center islands, and the necessary precautions against ambush which must be taken when

approaching a riverbank all too often supply the necessary advantages which allow the enemy to escape.*

A boat marking system might be employed for two basic purposes to hamper V.C. movement of contraband cargoes. First, it could be used by PBR crews to determine which boats should be thoroughly searched. Strips of phosphors would be laid across all the water approaches to a V.C. base area in the same manner as already discussed for legitimate cargoes. Then any marked boat found in the main channel would at least be suspect and a search and interrogation of the crew might be well worth while. This could prove especially useful as the V.C. sometimes travel in convoys of legitimate vessels. If the convoy is stopped by a PBR patrol, unless by pure chance the V.C. boat is singled out to be searched first, it usually has time to reach the safety of the banks, center islands, or side channels. A boat marking system might enable the PBR's to spot V.C. suspect vessels much more quickly among their cover of legitimate companions.

The second major advantage of a simple boat marking system in V.C. contraband operations is that it allows the PBR's to detect suspect craft when they are empty and do not fear being stopped by patrol boats for search and inspection. For when the V.C. vessels are loaded with contraband they take elaborate precautions to avoid contact with Game Warden patrols and will often successfully escape. If a boat marking system is employed, however, it is likely that many contacts will be made with empty V.C. contraband carriers after they have delivered their cargoes and no longer fear the approach of a patrol boat. Thus, such a system might allow the PBR's to detect and capture suspect craft at little risk to themselves.

*A favorite V.C. trick is to use boats to lure PBR's and other patrol boats close to prepared ambushes along the river banks or over mines.

Problem #3: Fishing Fleets

Near the mouths of many of the Delta's rivers, fishing is a major source of livelihood, and much of the fishing is done at night. It seems that the V.C. use these fishing fleets to mask their activities. They will use the legitimate fishing fleets as staging areas for their own river movements. It is almost impossible for two PBR's to control these fishing boats and if they begin to search the boats individually the V.C. vessels usually have time to escape.

A boat marking system could prove useful because it might enable the PBR's to identify suspect vessels in a fishing fleet for subsequent search quickly enough to prevent escape.

Problem #4: Aerial Spraying: "Lemon Squeezer" and "Firefly" Operations

Because of the vulnerability of the PBR's to ambush from the shores and their inability to enter narrow canals and side channels, PBR patrols began operating in conjunction with helicopters in what has become known as "lemon squeezer" and "firefly" operations. A lemon squeezer patrol is usually conducted at night and is composed of three helicopters and at least two PBR's. One helicopter, equipped with a powerful searchlight, goes first to locate any boats on the canals, rivers, or hidden in outer islands or along the banks. Upon spotting any suspicious boats the lightship orders them out into the center of the channel for the PBR's to inspect. If the boats refuse or try to evade the PBR's, the two trailing helicopters attack them.

While such operations have been successful, it is often impossible to destroy a large percentage of boats actually attacked in this manner.

Officers who have participated in such operations say that it could be helpful to mark boats attacked in these operations for possible later identification. If a 3-5 gallon spray tank were attached to one of the helicopters, it could be possible to mark most boats within a square kilometer. While this would not guarantee the subsequent apprehension of boats which escape the helicopter and PBR attacks, it would allow any American officer who later stopped one of these boats to know that the boat was attacked by a lemon squeezer force at a particular place and time.

Problem #5: Harbor, Beach, and Village Checks

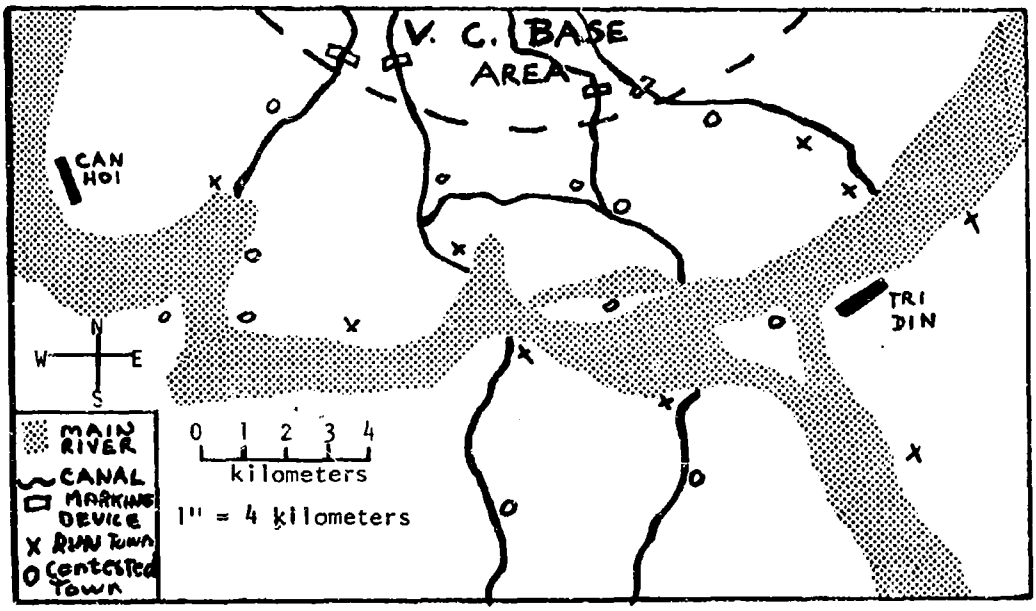
If the security risks involved in placing the necessary lights in the hands of selected South Vietnamese police and army units were justified, it might be possible to apprehend some V.C. boats and crews which are actually based in government-controlled or contested areas.*

For example, let us turn to Map III on page 27. Let us again assume that a V.C. base area is located north of our major river as indicated on the map and that there are several government-controlled towns and contested hamlets as indicated. Our intelligence tells us that the V.C. are using several of these government-controlled and/or contested villages to buy supplies and that some of the boats in these hamlets are engaged in delivering these supplies to the V.C. base area indicated on the map.

As in the first three situations the channels leading into the V.C. base area would be marked. Then RVN and/or American personnel would make

*Several PBR officers have indicated that the V.C. seem to frequently base their supply boats in government and contested villages to provide cover and protect them from air and artillery strikes.

MAP III



daily inspections of the boats while they were berthed or beached in their villages in order to identify marked boats which had entered the enemy's base area.

Problem #6: Curfew Enforcement

If it is desirable and politically acceptable, a boat marking system could be used to help enforce the curfews which are in effect on almost all of the Delta's major and minor waterways. By placing marking systems, which are timed to turn themseives on and off to coincide w th the curfew hours in a specific locality, at strategic places on the waterways, it would allow PBR's, village police, junk force boats, etc., to identify curfew violators. Whether it is helpful or practical to acquire this capability, however, would depend on the military, social, and political situation in each given area.

Problem #7: Intelligence Uses

In addition to a few of the basic potential uses of a simple boat marking system already discussed, there is a wide range of possible intelligence gathering uses. The basic system has the capability of determining whether or not a boat has passed the location of the dispenser within a certain period of time.

Thus such a system might prove useful in any situation in which the answer to whether a boat has crossed a particular line during a particular time period was necessary.

While individual commanders probably could find many specific intelligence uses for a boat marking system to suit each environment, need, and operation, a few possible uses are listed below:

1. Establishing normal traffic patterns in a given area.
2. Tracing the route taken by a suspect craft.
3. Determining approximate delivery points and schedules for goods destined for a V.C. base area.
4. Determining whether a boat has made a long or short journey.
5. Monitoring and possibly controlling waterborne infiltration from Cambodia.

Problem #8: Insertion of Underwater Dispersing Devices

A wide range of possible methods might be available for placing the necessary marking devices in selected waterways in the Delta. Some of these are briefly outlined below.

PBR Delivered. In some cases the PBR's themselves should be able to insert the devices. Boat commanders have stated that they could carry several smaller (under 10 gallons) devices without any problem or degradation

of the boat's performance. The PBR's could only be used, however, for this purpose in areas where they normally patrol, unless some changes are made in the areas covered by these boats. In those areas which are patrolled only in daylight but in which a nighttime marking capability is desired, the PBR's could plant marking devices in daylight which were set to turn themselves on at the proper time.

Junk Force. The South Vietnamese Junk Force with American advisers patrol many of the smaller waterways in the Delta. These units could be utilized to drop disseminators in some cases. The fact that this force is made up of Vietnamese personnel, however, might increase the V.C.'s knowledge about the boat marking system as the enemy has probably succeeded in penetrating this force with its agents.

Aerial Delivery. Probably the best method of implanting marking devices, especially in waterways well within known V.C. base areas, would be by helicopter. In many areas helicopters could probably drop the devices into the selected waterways at night in order to lessen the chance of being observed. It would be difficult for the V.C. to ambush helicopters engaged in these missions because there would often be several miles of each waterway in which the marking device could be dropped. Thus the V.C. would have to cover several miles of each canal in order to ambush a helicopter. To decrease the chances of the enemy discovering the true nature of the helicopter's mission, it might strafe the banks of the waterway where this is practical. Light fixed-wing aircraft might also be employed to insert marking devices. The Quiet Aircraft (modified, powered gliders) being developed by Lockheed for the Special Forces might be ideal

for such missions. These planes are being designed to be inaudible to the human ear at distances in excess of 100-500 feet.

SEAL Delivery. In some areas, such as the Rung Sat Special Forces Zone, southeast of Saigon, the Navy's SEAL teams penetrate deep into enemy territory on a wide variety of intelligence and combat missions. While the Navy personnel connected with these operations were understandably guarded in their comments, they did indicate that SEAL teams would have little trouble placing small dissaminators in the normal course of many of their operations.

V. TACTICAL ADVANTAGES AND WEAKNESSES OF A SIMPLE BOAT MARKING SYSTEM

While many of the advantages and weak points of a simple phosphor boat marking system have necessarily been pointed out in the preceding sections, it might be helpful to briefly discuss the system with this in mind.

A. Advantages

The basic advantage of the use of a simple boat marking system in the Delta is that such a system supplements, rather than replaces, our present Game Warden, junk force, and police activities. Its use in Game Warden operations would not require the PBR's to alter their patrolling methods or operating procedures. For the system is designed to help these patrols accomplish their present mission. The only additional tasks which the PBR crews need perform is handling the lights used for detecting a marked vessel. Since the PBR's already approach within point blank range of a substantial minority of all boats sighted, the system's limited range would not be a critical handicap in these cases. In other words,

the system would be useful, without any changes in tactics, because it would enable the PBR crews to determine which of the boats they had succeeded in inspecting and/or searching had entered V.C. areas. The system is not designed to increase the number of enemy boats with which the PBR's come in contact but rather to increase the probability that they will recognize an enemy boat when it is spotted.

The additional equipment necessary to equip the PBR's would be minimal as most already have infrared gear. Probably the only additional piece of equipment necessary would be some variety of ultraviolet searchlight and/or a tubular device for close inspection of another boat's hull.

In addition to its supplementary nature, a simple boat marking system is designed to make use of and increase the operational value of the kind of intelligence information which is most available to operational commanders in the Delta. For the most common kind of intelligence information is not class A intelligence which might state that Co Van Tri is taking a sampan full of arms by the following route on Friday at 10:30 in the morning from Tri Den to Phu Chi. Rather, the most plentiful form of intelligence is of a much more general nature. It gives approximate locations of enemy base areas, villages in which the V.C. are suspected of buying supplies, canals and rivers leading into base areas, etc. At the present time such information is only marginally valuable for planning specific Game Warden operations because of the large volume of this type of information and its general nature. For example, a PBR base commander might receive information that the V.C. are buying supplies in several villages in his area and using one and/or several of ten possible routes to transport these supplies to a base somewhere in a 10-square-mile area.

A commander of a 15-25 PBR detachment might have several such pieces of intelligence information. But even if he decided to reduce the number of normal patrols in order to stake out possible routes leading into a suspected V.C. base area, he probably would not have enough boats to successfully watch all of the channels leading into that area. Also, because of the enemy's usually good intelligence and sentry systems, it would be doubtful whether the V.C. would use the channels being watched by the PBR's.

A workable boat marking system would allow Game Warden operations to take advantage of this general intelligence information; for although it is not possible to use PBR's both to stake out all suspected V.C. routes and maintain normal patrol schedules, it might be possible to use the boat marking system to mark all vessels which use these routes for later identification if they are stopped by PBR's in the future.

Because the system is non-lethal, a higher false alarm rate is acceptable than for lethal systems. The system is only intended to be used to increase the efficiency of screening suspect boats from the normal civilian traffic flow. Thus, if an innocent boat is marked, the worst that would happen to the boat's crew would be the inconvenience of being detained for interrogation. In those cases where an innocent boat was marked because it was violating curfew, this inconvenience might even serve as a deterrent to future curfew violations.

The system is basically ultra-simple and would require virtually no additional training to teach the PBR crews to operate and maintain. The chemicals are safe, non-toxic* and present few storage problems. If the most simple pressure-actuated disseminator is practical, the disseminating

*See Appendix I for toxicity studies.

system would have no moving parts. The simplicity of the system while an advantage in itself, also helps insure the quick availability of an operational system. The system might possibly be ready to employ on a limited basis within 2-4 months of the time the decision was made to go ahead.

If the system succeeds in seriously hampering the enemy's supply system it might have several important effects on the war in the Delta. At first, the enemy might conceivably place the blame for the seemingly mysterious capture of his boats on an informer within his own ranks. The subsequent suspicion and tightening of security might further reduce the efficiency of his supply operations. By making what used to be extremely safe jobs more hazardous, more V.C. supply boat crews might be persuaded to defect or refuse to work for the V.C.; for many of these crews seem to be made up of ordinary villagers who are forced by threats into part-time V.C. service.

With the introduction of American ground units into the Delta and the increased emphasis on pacification programs and population control, the efficiency and value of a boat marking system might improve significantly. For as the areas of government control expand, V.C. base areas are defined, and the boundaries between government- and V.C.-controlled areas become more definite; the areas in which a boat marking system can be used and the value of knowing who enters these areas should increase.

B. Weaknesses and Countermeasures

To evaluate the possible effectiveness of any system it is essential to consider the dynamic nature of any wartime situation. Often what will work in a laboratory or on a test range might not work against a real enemy under actual combat conditions. To the best of our ability then, we

must try to put ourselves in the V.C.'s place and see what might be done to negate or decrease the effectiveness of a boat marking system.

First, let us discuss how much the V.C. would probably know about any boat marking system which was employed in Vietnam. The nature of security within the RVN government and armed forces would make it extremely unlikely that the general nature of any boat marking system employed in Vietnam could be kept secret for very long. Within a month after the system was used on a major scale, the V.C. would probably be aware that some kind of marking or tagging system was being employed to apprehend boats which had previously been unmolested.

How long it would take him to discover that underwater dispersing devices placed in canals and rivers leading to his base camps were responsible for marking the boats is a matter of conjecture. However, it must be assumed that even without the benefit of covert intelligence, the V.C. would acquire this knowledge by observing the dropping of the marking devices, prisoner interrogation, etc. If a straight ultraviolet system is used, some of the covert nature of the system will be more quickly compromised as the marking agents glow visibly when illuminated by an ultraviolet light source. If the system which employs a marking agent which is illuminated by ultraviolet light, but emits in the infrared is used, however, the "mysterious" nature of the system could probably be preserved for a longer time because the marking agent is not visible to the naked eye when illuminated by ultraviolet light.

While the details of the system can probably be kept a secret for a short period of time (2-6 months), it must be assumed that eventually the V.C. will acquire a fairly accurate picture of its nature, its uses, and

its component parts. We must remember, however, that the information will probably reach the enemy in a piecemeal fashion, and it will probably take some additional time to correlate his intelligence and to recognize the validity of his tentative conclusions.

Once the V.C. understand the nature of the boat marking system, they must then disseminate this information both to all affected local units and up the chain of command toward Hanoi. My own knowledge of the V.C. chain of command and control is limited, but it does seem probable that such a process might consume a considerable amount of time. In addition, while the system seems extremely simple to the average American, for some of the lower level uneducated V.C. peasants who must deal with it, the system might still seem complex and mysterious.

Thus it would probably take the V.C. a certain amount of time to discover the nature of the system being employed against them and to disseminate this information. This knowledge, however, is of only marginal value unless effective countermeasures can be devised and implemented; and we must remember that the same rigid doctrines, static bureaucracy and communications problems which could hamper efforts to discover and disseminate the nature of the system would exist in devising and implementing countermeasures. Let us now briefly examine some of the most important measures which the V.C. could take to decrease the usefulness of a simple boat marking system such as the one discussed in this study.

Perhaps the most logical measure to negate a boat marking system would be for the V.C. to keep all their supply vessels which are likely to be marked out of areas in which they are likely to encounter Game Warden or other allied patrols. To do this, however, would seriously

damage the effectiveness of V.C. supply operations. For few of these areas are contiguous, and to move from one V.C. base area to another often requires enemy boats to traverse government-controlled and patroled waterways. While to some degree the V.C. can certainly decrease the number of boats which traverse allied-controlled and/or patroled waterways, it is doubtful whether this could be accomplished to a degree that would negate the system without seriously damaging the enemy's supply system and capabilities.

This approach, however, might be somewhat simplified if the V.C. could acquire the necessary detectors to determine which of their boats were actually marked. The acquisition of ultraviolet lights is not in itself difficult as they are commercially available; small, portable units, however, are available on a much more limited scale. Even if the necessary lights were acquired, the problem of distributing them to the thousands of small vessels engaged in V.C. activities would be difficult as would be the problems of maintenance and battery supply. To acquire the necessary infrared equipment and image intensifiers to identify boats marked with the infrared-emitting phosphors would be far more difficult. For these devices are not commercially available and are fairly expensive and sophisticated pieces of equipment. To acquire them in significant quantities, the V.C. would probably have to turn to the Soviet Union, and even then some development and/or modifications might be necessary.

Perhaps one of the most effective countermeasures which could be employed against a simple boat marking system under certain circumstances would be the transshipment of cargoes using two boats to deliver one cargo. For if the enemy could use one clean unmarked boat to carry a cargo on the

rivers and canals which are patroled by Game Warden forces and then transfered their cargo to another boat originating from the V.C. area to which the supplies were being shipped, there would be little probability of PBR's on the main river channel encountering a marked boat. While in some areas transshipment might provide an effective countermeasure, in many areas this technique would be less useful. Also, there are a number of serious problems which the enemy would encounter in trying to make use of transshipment operations.

The first problem would be that the V.C. could never be certain exactly where a safe unmarked stretch of waterway ended and a marked section began. The implanting of several different marking devices in the same canal, each with its own color-coded marking solution, would greatly increase this problem. Second, it would increase the number of boats needed for each operation. Although turnaround times would probably be reduced for each boat involved in some cases, the unloading and loading operations and lengthy routes needed to reach a safe transshipment location would probably reduce many of the advantages of reduced turnaround time. Third, transshipment would greatly complicate the present supply system. Messengers, additional sentry boats, more manpower, and the necessity of more covert operations for even "legitimate" cargoes are just a few of the problems which the V.C. would have to overcome. Fourth, with bulk cargoes such as rice, transshipment is a laborious and time-consuming operation. Fifth, transshipping increases our chances of apprehending V.C. supply craft by normal patrol and intelligence operations. For if transshipment operations are carried out in government-controlled sections of waterway which are likely to be unmarked, the chances of this operation being discovered by our patrols or of learning of these operations by conventional intelligence means

is increased. On the other hand, the closer the transshipment points are to V.C.-controlled areas, the greater the likelihood that both boats involved will pass through marked stretches of waterway.* Finally, the use of these methods by the enemy would necessitate the basing of larger numbers of supply craft in V.C.-controlled areas or bases. At the present time, the V.C. can base many of these boats in government-controlled or contested villages. The present basing policies make it harder to pinpoint V.C. base areas and increase the safety of these craft from bombing and artillery attacks.

While it does seem that transshipment would offer the enemy a somewhat effective countermeasure under special conditions, the above-mentioned costs might often prove prohibitive. Also, for every countermeasure there is often a counter-countermeasure. And if the enemy makes these techniques effective over a period of time, it is not at all uncertain that inventive area commanders will be able to figure out how to negate these steps.

An extremely heavy oil is commonly used in South Vietnam to calk boats. It is probable that this oil could be used to cover the phosphors on a boat so that they could not be detected. To be completely effective, however, this process would have to be repeated whenever a boat which is going to cross a patroled area thought that it might have crossed a marked stretch of waterway. Extreme care would have to be exercised to cover every inch of the area above and below the boat's waterline to avoid detection. If the V.C. began to effectively employ this countermeasure,

*Once it was recognized that the V.C. was employing this technique, it might be effectively countered in many cases by changing the locations of the marking devices.

Game Warden patrols might begin to pick up for search and interrogation all freshly calked boats.

Another measure which the V.C. might employ would be to attempt to mark innocent civilian boats. If enough friendly boats in a particular area were marked, this would raise the "false alarm" rate to a high enough level to seriously impair the effectiveness of a boat marking system.

Two methods of marking friendly boats seem possible. The first is for the V.C. to force legitimate boats to cross marked strips of waterway. The second is for the V.C. to secure the proper marking chemicals and spread them in areas where legitimate boats are likely to pass.

If proper security and control measures were exercised over the phosphors, it is unlikely that the enemy could acquire sufficient quantities to mark large numbers of legitimate vessels. While many kinds of phosphors are commercially available, some of the more specialized varieties which could be used are available in the United States on a proprietary or classified basis only. Also, if this technological kind of countermeasure were employed against us, it would seem that the United States would have a tremendous advantage over North Vietnam, China and even the U.S.S.R. in rapidly developing and deploying new types of phosphors.

Even if the V.C. succeed in occasionally forcing friendly boats to cross marked stretches of rivers and/or acquire the proper phosphors to mark legitimate boats, this might only marginally influence the effectiveness of a boat marking system. For the large number of codes available for use in the marking chemicals would allow us to change codes almost daily on a random basis. This might make it extremely difficult for the enemy to negate the system by marking legitimate boats.

To summarize, there is a wide variety of possible countermeasures available to the V.C. against a simple boat marking system. None of the countermeasures discussed in this section, however, would render useless a system which was used on the basis of good intelligence information. In addition, most countermeasures would seem to entail changes, inconveniences, a decrease in efficiency, or logistical difficulties for the present enemy supply system.

VI. REMAINING RESEARCH, DEVELOPMENT AND TESTING

While most of the chemicals, and other equipment for a boat marking system are either on-the-shelf or extremely easy to design, there is still a certain amount of work to be done before a system should be sent to Vietnam for evaluation. The necessary work remaining to be done is briefly outlined in the following sections.

A. Dispensing Devices

American Cyanamid has demonstrated the feasibility of the underwater pressure-activated dispersing device described in this study. Their test devices, however, differ from what the probable final configuration would be in several important ways. The Cyanamid device was suspended from marker buoys floating on the surface of the water. This method, for obvious reasons, would not be suitable for an operational system. Rather than surface anchoring, it would be necessary to anchor the device from the bottom of river, stream or canal so that no evidence of its location would be visible on the surface of the water.

To convert the Cyanamid devices only two simple modifications are necessary. First, an anchor and rope must be attached to the container.

Second, since the Cyanamid device does not float, some buoyant material must be incorporated or attached so that the device can be anchored from the bottom of the waterway. Neither of these two modifications present any problems.

If a battery-powered, simple screw-feed disseminator is desired, it would be necessary to develop and test a new device from scratch. This task, however, should be relatively simple. The basic components such as electric motors, screw feeds, batteries, timing devices, and containers are already on the shelf. What remains to be done is to select and match the desired components to make a complete working device.

If the ability to turn the disseminators on and off to coincide with hours of curfew is desired, a clock-actuated shut on and off mechanism must be designed and incorporated into the device. The people at the Naval Operations Support Group in Coronado, California and at Metronics Associates, Incorporated, say that this is a simple problem to solve and that some standard devices might be suitably modified to do this job.

In addition to these modifications, it would be advisable to incorporate a self-destruction mechanism into the device to prevent the acquisition of it and its marking solution by the V.C. Perhaps one simple method would be to set a sma'i explosive charge to destroy the device if the anchor cable is severed and/or the anchor is removed from the bottom of the waterway.

B. Marking Chemicals and Solutions

Almost all of the necessary laboratory work on suitable marking agents has already been done. The American phosphor industry is

adva and offers many usable marking chemicals. In addition, there have been many government contracts dealing with the development and selection of candidate marking phosphors for a wide range of marking and identification systems. None of this work, however, has been designed to select marking chemicals to best meet the requirements of a simplified boat marking system. American Cyanamid, Edgewood Arsenal, and Leusona Hoos, to name a few, have developed a wide range of marking phosphors applicable to such a system. What remains to be done in this field is to select those phosphors which best conform to the specific operational requirements of the simple boat marking system described in this study.*

In addition to phosphor selections, it might be wise to designate a basic set of possible colors and combinations of different types of phosphors to be used as codes. This would be a relatively simple job, especially if the initi system required only a few dozen easily distinguishable codes.

C. Lights and Detectors

As with the necessary phosphors, the basic work left to be done in this field is primarily one of selection and modification rather than new research and development. For there is a wide range of commercially available, military issue, and prototype, ultraviolet, infrared and image-intensifier equipment which would be suitable for a simple boat marking

*This is the short-term requirement. If the system proves feasible, effective, and desirable, it probably would be possible to increase its performance by developing new phosphors specifically for this type of operation.

system. In fact, many PBR's are already equipped with the necessary starlight and infrared devices. All that really remains to be done is to select and adopt an ultraviolet light source which best meets the specific operational requirements of a simple boat marking system.

D. A Note on Systems Integration and Possible Long-Range Development Programs

It is necessary to point out at this time that the remaining work to be conducted, especially in the fields of phosphor and light selection, should be carried out in close conjunction. For to a certain extent, the types of phosphors eventually selected will influence the types of detection lights employed and vice versa.

While this study is mainly concerned with a boat marking system which could be largely constructed from on-the-shelf items in under six months, it is possible that considerable improvements could be made by a longer range (1-2 years) research and development program specifically designed to develop a simple boat marking system to conform with stated operation requirements of our forces in the Delta. Much of this work should be concentrated on increasing the range of detection to perhaps 100-200 feet.

E. Testing Phase

Before a system is sent to Vietnam for evaluation, a certain amount of operational testing should be conducted in the United States to get some answers to the many questions left unanswered by the simple feasibility testing conducted by the American Cyanamid Company. Perhaps the ideal location for such testing would be at the Naval Amphibious Base facilities at Coronado, California and at the PBR Training School at

More Island, California where the necessary small, medium and larger waterways, the PBR's, and V.C.-style junks and sampans are available.

Some of the more important questions which a testing program should be designed to answer are briefly listed and discussed below.

1. Range at Which Detection is Possible

While the simple experiments conducted by American Cyanamid and the work done by the Edgewood Arsenal have yielded what should turn out to be fairly accurate estimates of the effective range of a simple boat marking system, it would be useful to examine the effective range of the system under simulated operational conditions. Exercises should be designed to determine the actual range of both ultraviolet and infrared emitting systems under various lighting and weather conditions. Detailed scientific measurements and complicated experiments, however, would probably not be necessary. What would be important is to acquire a feel for the range limitations of the system during actual operational use in various possible lighting and weather conditions.

2. Optimum Rate of Marking Solution Release

The American Cyanamid experiments in the Tuckanoe River in New Jersey demonstrated that one gallon per hour of a solution containing 1% by weight of marking material was sufficient to effectively create a one-eighth to one-fourth mile strip across a 300-meter wide river so that any boat crossing this strip would be effectively marked. These experiments, however, were not designed to find out what the ideal rate of release should be; they merely found that one gallon per hour did the job. Questions which should be generally answered are:

a. What is the minimum rate of release which will effectively mark a boat at a given distance downstream from the disseminator?

b. What effect does a given increase in the rate of phosphor release have on the distance downstream from the disseminating device at which a boat can be marked?

c. What effect does a given increase or decrease in the rate of release have on the amount of phosphors actually deposited on a boat passing through the marked stretch of waterway?

d. Does a given increase or decrease in the rate of release substantially effect the ease of identifying a marked boat or the range at which identification can be accomplished?

e. What rate of release is necessary to mark a given area of stagnant water for a given period of time?

f. What are the effects of changing tides on the system?

g. Can the marking chemical be detected on the surface of the water at operational release rates by use of the proper UV and IR lights?

F. Persistency of Marking Solution on Boats

No formal experiments have been conducted to determine how long a boat passing through a marked section of waterway remains marked. Exact information is not needed, but the acquisition of some general parameters is essential. Also it would be helpful to determine if it is possible to distinguish between boats which have been relatively recently marked and those which were marked a relatively longer time before.[*]

G. Ease of Code Recognition

Color and combination of different types of phosphor codes which are easily distinguishable in a laboratory might not be so easy to read under actual operational conditions. Therefore, it is important to verify the readability of each code intended for actual combat use.

[*]American Cyanamid's work indicated that this could easily be accomplished by employing phosphors which would lose their fluorescent qualities from one day to four weeks after one were exposed to moisture and/or sunlight.

H. Simulated Operations

It probably would be extremely helpful if at least several simulated exercises in which the use of a boat marking system was employed were carried out. The exercises might employ the system for several of the basic operational uses described in this study or any other uses deemed desirable.

VII. CONCLUSIONS AND RECOMMENDATIONS

While the various ideas in the field of marking and identification have been discussed in reference to the war in Vietnam for several years and many technical systems have been developed, one major factor has minimized the support given for the actual operational use of any of these systems. This is the lack of specific operational requirements from our forces in Vietnam. As a result, the research and development people working in this field often lacked the necessary guidelines within which to design a specific system for specific operational uses. More importantly, however, the apparent lack of specific operational requirements from the field for a boat marking system has exercised a critical influence on those responsible for evaluating the operational potentials of such a simple system.

It is the contention of this report, however, that an important operational requirement for a simple boat marking for use with Game Warden and related operations in the Mekong Delta does indeed exist. This contention is based to some extent on printed material but is mainly based on discussions and interviews with naval personnel who have served in Vietnam on these operations. For the last three months much of my time has been spent talking to naval personnel in Washington, D.C., U.S. Naval Amphibious

Base at Coronado, California, and at the PBR Training School at Mare Island, California. While the Vietnam experience and opinions of these men varied widely, all stated that they felt there was an operational requirement for a simple boat marking system to be used on the basis of current intelligence information. The scenarios presented in this study are largely based on the information and suggestions provided by veterans of the Delta's waterways.

In many ways, it seems that the major reason for the lack of a specific operational requirement for the systems described in this study is that the men actually engaged in patrolling the Delta's waterways are unaware of the existence, nature and capabilities of a simple boat marking system. Therefore, probably the first logical step would be to give a thorough briefing on the nature of the system to U.S. Navy personnel actually engaged in patrolling the Delta waterways. This would serve to verify the operational requirements for such a system. In addition, they could probably provide valuable advice, modifications and additional uses for the system because of their daily contact with the problems.

If the men engaged in Delta waterway operations express a sufficiently favorable interest in the system, then attention should be turned to resolving the technical and operational questions raised in this study. While some suggestions and ideas in this direction have been tentatively presented, there are still many details which must be worked out. This study, however, is still in too early a stage to justify or allow a detailed presentation of all these aspects.

If the usefulness of a simple boat marking system is to be maximized, at least the initial phases including the briefing of selected naval personnel in Vietnam and some tentative testing should be accomplished as

quickly as possible. Speed is important so that the system can take advantage of the initial impact and knowledge gained from the introduction of U.S. ground troops into the Delta and the increased attention being given to pacification efforts.

In summary, it appears that a boat marking system could be constructed largely from on-the-shelf items in under three months, and that there is an operational requirement for such a system. In addition, it might have a significant effect on the enemy's water mobility and supply systems if employed in the proper manner without disrupting present operations.

APPENDIX I

REPORT ON THE TOLERANCE OF GOLDEN SHINERS (NOTEMIGONUS CRYSOLEUCAS) TO ARPA WATER COMPOUNDS

by

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October 1966

I. Statement of the Problem

The laboratory was requested by Dr. M. Beachem to determine the toxicity of ARPA Water Compound R6882-168 by fish bioassay. The test fish would be Notemigonus crysoleucas (golden shiner) and the water would be taken from the Raritan River at Bound Brook, New Jersey.

II. Objective of the Study

The objective of the test was as follows:

To evaluate the toxicity of the compound to golden shiners.

III. Summary

From the data developed, it is indicated that:

(1) Compound R6882-168 is not toxic to golden shiners at concentrations of 200 mg./sq. ft. to 400 mg./sq. ft.

IV. Procedure

The tests were run in triplicate with golden shiners. The fish ranged in size from 7 to 10 cm. and were free from disease during the laboratory storage and experimentation. The stock was secured from the Stanhope Sports Shop, Stanhope, New Jersey.

The bioassay tests were run in accordance with the U.S. Public Health Service procedure set forth in the APHA Standard Methods for the Examination of Water and Waste Water - 12 Edition, 1965.

The water from the Raritan River was taken at the American Cyanamid pump intake and transported to the laboratory in a 55-gallon drum. The water was transferred to glass jars and brought to 20° C. before the fish were added. The testing consisted of batteries of 5-gallon, wide-mouth jars each containing 10 liters of river water and five fish. The fish were checked at 24-hour intervals and the dead fish removed. The time of survival is set by the observation interval--fish found dead at this time may have died at any time between the recorded time and an earlier interval.

The test solutions were analyzed for pH, dissolved oxygen, alkalinity, total hardness and chlorides at the start and finish of the test.

TABLE I

TOLERATION OF GOLDEN SHINERS TO COMPOUND R6882-168

		Percent Survival			
Concentrations (mg./sq. ft.)		0	200	300	400
Test No.	(Hours)				
(1)	0				
	24	100	100	100	100
	48	100	100	100	100
	72	100	100	90	100
	96	100	100	90	100
(2)	0				
	24	-	100	100	100
	48	-	100	100	100
	72	-	100	100	100
	96	-	100	100	100
(3)	0				
	24	-	100	100	90
	48	-	100	100	90
	72	-	100	100	90
	96	-	100	100	90

TABLE II

CHEMICAL ANALYSES

Test No. 1

Start

Concentration (mg./sq. ft.)	0	200	300	400
pH	7.3	-	-	-
Alkalinity (p.p.m.)	42	-	-	-
Hardness (p.p.m.)	112	-	-	-
Chlorides (p.p.m.)	16	-	-	-
DO (p.p.m.)	7.5	-	-	-

Finish

pH	7.3	7.3	7.2	7.2
Alkalinity (p.p.m.)	47	56	56	58
Hardness (p.p.m.)	121	118	117	116
Chlorides (p.p.m.)	18	18	18	17
DO (p.p.m.)	8.0	7.9	7.6	6.7

Test No. 2

Start

pH	7.3	-	-	-
Alkalinity (p.p.m.)	42	-	-	-
Hardness (p.p.m.)	112	-	-	-
Chlorides (p.p.m.)	16	-	-	-
DO (p.p.m.)	7.5	-	-	-

Finish

pH	7.3	7.3	7.1	7.2
Alkalinity (p.p.m.)	47	55	56	51
Hardness (p.p.m.)	121	120	116	114
Chlorides (p.p.m.)	18	18	17	17
DO (p.p.m.)	8.0	7.6	5.7	8.5

Test No. 3

Start

pH	7.3	-	-	-
Alkalinity (p.p.m.)	42	-	-	-
Hardness (p.p.m.)	112	-	-	-
Chlorides (p.p.m.)	16	-	-	-
DO (p.p.m.)	7.5	-	-	-

Finish

pH	7.3	7.4	7.2	7.4
Alkalinity (p.p.m.)	47	56	52	54
Hardness (p.p.m.)	121	115	116	113
Chlorides (p.p.m.)	18	18	19	17
DO (p.p.m.)	8.0	8.8	7.1	9.0

Discussion of Results

The data indicate that Compound R6882-168 is not acutely toxic to golden shiners at the concentrations tested.

END
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